CLAIMS

WHAT IS CLAIMED IS:

1. A method of petrophysical evaluation of a formation comprising:

(a) using values of horizontal and vertical resistivities of the formation and deriving therefrom an estimate of water content thereof;

(b) using NMR measurements of the formation and deriving therefrom an estimate of bulk irreducible water content of the formation;

(c) comparing the estimate of water content with the estimate of bulk irreducible water content of the formation; and

(d) obtaining a parameter of interest of the formation.

2. The method of claim 1 wherein deriving said estimate of water content further comprises:

(i) inverting said values of horizontal and vertical resistivities of the formation using a tensor petrophysical model to give a first estimate of fractional volume of laminated shale in the formation;

(ii) obtaining measurements of density and/or neutron porosity of the formation and using a volumetric model for deriving therefrom a second estimate of fractional volume of laminated shale; and

(iii) if said second estimate of fractional shale volume is greater than said first estimate of fractional shale volume, inverting said horizontal and vertical

resistivities using a tensor petrophysical model including said second estimate of fractional shale volume and obtaining therefrom a bulk water content of the formation.

3. The method of claim 1 further comprising determining a vertical and horizontal resistivity of an anisotropic sand component of the formation and determining therefrom and from at least one additional measurement selected from the group consisting of: (i) NMR measurements of the formation, and, (ii) a bulk permeability of the sand component, a parameter of interest of a coarse and a fine grain portion of the sand component.

4. The method of claim 1 further comprising using a transverse induction logging tool for obtaining said values of horizontal and vertical resistivities of the formation.

5. The method of claim 1 further comprising using an induction logging tool for obtaining said values of horizontal resistivities and a focused current logging tool for obtaining said values of vertical resistivities.

6. The method of claim 1 wherein the tensor petrophysical model further comprises a laminated shale component and a sand component.

7. The method of claim 1 wherein using said volumetric model further comprises using at least one of: (i) the Thomas-Stieber model, and, (ii) the Waxman-Smits model.

8. The method of claim 3 wherein said parameter of interest is selected from the group consisting of: (A) a fractional volume of said coarse grain component, (B) a fractional volume of said fine grain component, (C) a water saturation of said coarse grain component, (D) a water saturation of said fine grain component, (E) a permeability of said coarse grain component, and, (F) a permeability of said fine grain component.

9. The method of claim 3 wherein the at least one additional measurement comprises an NMR measurement, and deriving the parameter of interest further comprises deriving a distribution of relaxation times from said NMR measurements and obtaining therefrom a distribution of components of said anisotropic sand.

10. The method of claim 3 wherein the at least one additional measurement comprises a bulk permeability measurement of the anisotropic sand and deriving the parameter of interest further comprises:

A.. obtaining a family of possible distributions of volume fractions and bulk irreducible water content (BVI) for the coarse and fine sand components;

B. determining horizontal, vertical and bulk permeability values associated

with said family of possible distributions; and

C.. selecting from said family of possible distributions the one distribution that has a determined bulk permeability substantially equal to the measured bulk permeability.

11. The method of claim 10 wherein said bulk permeability is obtained from the group consisting of (I) NMR diffusion measurements, (II) a formation testing instrument, (III) a pressure buildup test, and, (IV) a pressure drawdown test.

12. The method of claim 10 wherein determining the horizontal and vertical permeability values associated with said family of distributions for the coarse and fine sand components further comprises using the Coates-Timur equation

$$k = \left(\frac{\phi}{C}\right)^a \cdot \left(\frac{\phi - BVI}{BVI}\right)^b$$

where k is a permeability, ϕ is a porosity, BVI is the bound volume irreducible, and a, b, and C are fitting parameters.

13. The method of claim 10 wherein determining horizontal, vertical and bulk permeability values further comprises using a relationship of the form

$k = C\phi^a T^b$

where k_e is a permeability, ϕ is a porosity and T is a NMR relaxation time, and a, b, and C are fitting parameters.

14. The method of claim 13 wherein T is a longitudinal NMR relaxation time.

15. The method of claim 2 wherein the tensor petrophysical model in (i) comprises at least one of (A) an isotropic sand component, and, (B) an anisotropic sand component.

16. The method of claim 10 wherein the coarse sand portion of the selected distribution is characterized by an irreducible water saturation less than an irreducible water saturation of the fine grain sand portion of the selected distribution.

17. The method of claim 1 wherein deriving the parameter of interest further comprises specifying a formation factor for a constituent of the formation.

18. The method of claim 10 wherein the determined bulk permeability is a spherical permeability related to the horizontal and vertical permeability values by a relationship of the form

$$k_{sph} = \left(k_h^2 k_v\right)^{\frac{1}{3}} .$$

19. The method of claim 12 further comprising specifying the parameters a, b and C.

20. The method of claim 13 further comprising specifying the parameters a, b and C.